

# Investigating Medicinal Plants' Efficacy in Treating Foodborne Diarrhea

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## ABSTRACT

Foodborne diarrhea remains a major global public health issue, particularly in developing regions where access to modern medical treatment is limited. Antibiotic resistance and the adverse side effects of synthetic drugs have prompted a renewed interest in traditional herbal medicine. This study investigates the therapeutic potential of medicinal plants traditionally used to treat foodborne diarrhea. Through extensive ethnobotanical surveys conducted across 720 communities and supported by pharmacological evaluations, including in vivo and in vitro assays, 31 medicinal plants were identified for further scientific inquiry. Laboratory testing confirmed significant anti-diarrheal properties in several plant species, including *Acacia nilotica*, *Andrographis paniculata*, *Brucea javanica*, *Daucus carota*, and *Piper betle*. Comparative studies with conventional treatments like loperamide revealed promising efficacy, with no reported side effects in animal or clinical trials. This study highlights the importance of integrating traditional plant knowledge into modern healthcare systems to enhance treatment accessibility and address antibiotic resistance. Further research and policy development are essential for the safe, standardized, and effective application of these medicinal resources.

**Keywords:** Medicinal plants, foodborne diarrhea, traditional medicine, ethnobotany, antimicrobial resistance, phytotherapy, herbal remedies.

## INTRODUCTION

Public health officials have always had challenges in preventing the spread of foodborne pathogens, including bacteria, viruses, and parasites. Although the technological advances in food preservation and food safety surveillance have improved, foodborne diseases continue to be a major health concern. The World Health Organization has estimated that millions of people die annually as a result of having consumed food and water that is contaminated by pathogenic microorganisms [1, 2, 3, 4]. In industrialized countries, however, diarrheal diseases resulting from the use of contaminated water and food are more frequently considered a major public health threat. Antibiotics are still the most commonly prescribed medication for treating foodborne diarrhea. However, the irrational use of antibiotics has led to the development of antibiotic-resistant bacteria worldwide. This antibiotic resistance problem is growing, and new antibiotics, therefore, are urgently needed [6, 7, 8, 9]. Recent decades have seen increasing interest in the use of plants as a source of alternative medicine. This has opened new avenues for discovering natural products with antibiotic activities. Medicinal plants are the major health care providers in traditional medicinal practices. Over 22,000 different plant species throughout the world are used in treating diseases and managing health problems. Traditional medicinal practices have, however, evolved over thousands of years, based on accumulated experiences from different practices. It is, therefore, important for continued scientific inquiries to explore the plant candidates that are known to traditional healers, herbalists, and people living in isolated villages or remote places [10, 11, 12, 13]. This paper aims to systematically investigate the efficacy of medicinal plants in treating foodborne diarrhea among 31 plant candidates that have been traditionally used. It is hoped that this paper will contribute to

supportive scientific data for the proper use of the resources and provide some leads for the discovery of new antibiotics [14, 15, 16, 17].

### Background on Foodborne Diarrhea

Diarrhea is described as an increase in the frequency, volume, and water content of the stool. It can be a mild, self-limiting acute illness, a chronic illness, or a symptom of other gastrointestinal illnesses. Persistent diarrhea contributes to malnutrition, growth developmental delays, and death. Globally, 1.7 billion cases of childhood infection and around 1.0 million deaths each year result from diarrhea. The majority of these cases are caused by foodborne infection, although it is often reported by contaminated drinking water. It is estimated that 0.92 million people of all ages die from foodborne diarrhea each year [18, 19, 20, 21]. Almost half of these deaths are in children below 5 years old, with deaths occurring in developing countries. This illness is a key public health issue and an important economic concern. In the majority of the foodborne outbreaks in developed countries, bacteria are responsible for the majority of episodes; half are attributed to viruses, while bacteria and parasites are responsible for the majority of outbreaks. In developing countries, most disease is presumed, but the cause is infrequently confirmed by laboratory testing. At least 4 diseases are generally indicated as foodborne diarrhea: typhoid, cholera, shigellosis, and E. coli infection. The other diseases are caused by bacteria, viruses, and parasites and are generally called foodborne illnesses or foodborne infections [22, 23, 24]. The prevalence of foodborne diarrhea in developing countries is somewhat higher than in developed countries. The average annual incidence of foodborne diarrhea in developed countries and less developed countries is, respectively, 10.68 and 41.0 episodes per person each year. Foodborne illnesses are frequently acquired in the home. The high-risk group for acquiring diarrhea is children 0-4 years old. However, mortality is maximum in the population 65 years and older. Currently, an attempt is made to minimize the risks of foodborne diseases by enhancing consumer awareness, appropriate cooking, and sanitary habits, and improving infrastructure for the provision of abundant and harmless food [25, 26, 27, 28]. Most foodborne organisms infect by contamination of food through hands. Hand hygiene will be needed to block the transmission of diseases. Beyond the difficulty in maintaining dependable chemical cleaning substances in their environment, these are potentially conducive growth media for irritating foodborne pathogens. Although there are synthetic drugs available on the market, they typically have adverse side effects. Therefore, most research is being carried out to find more efficient and improved oversight of the standard medications used. Similarly, this time around, the attention has shifted to the use of crops, also known as alternative treatments to diarrhea [29, 30].

### Medicinal Plants Overview

Plants have been the sources of medicine for centuries and have been used to treat diseases in different cultures worldwide. The use of traditional medicine (TM) is still surviving among people in the world today. It is estimated that there are roughly 250,000 to 500,000 species of higher plants in the world which nearly 50,000 species are used for medicinal purposes. Among these, only 5% of the higher plants have been investigated chemically. Numerous bioactive compounds like alkaloids, flavonoids, tannins, terpenoids, and phenolic compounds have been isolated. Foodborne diseases are caused by the consumption of contaminated food with different bacteria, fungi, viruses, and parasites. Among them, foodborne diarrhea is one of the common acute symptoms of gastrointestinal infections affecting both developing and developed countries [31, 32, 33, 34]. The use of plants for the treatment of foodborne diseases and diarrhea by different cultures is also well documented in the past. Medicinal plants are classified based on their therapeutically useful secondary metabolites. Medicinal plants used by different ethnic groups are based on their traditional culture, social, and geographical conditions, thereby creating a kind of medical ethnobotany. Investigation of medicinal plants widely used by different cultures, uncommon plants used by a particular ethnic group is intensifying in the past and at present, and plants are investigated for modern application. In the world, the maximum number of the population relies on medicinal plants for primary health care. Apart, Different medicinal plants are used for the treatment of diseases in the respective religions, ethnicities. Among them, some plants are globally used by human beings. The use of medicinal plants in the treatment of some diseases is also based on religious history, that is, the ancient compilation of Ayurveda in India. With the onset of scientific research and modern medicine, the rationale behind the optimism of traditional knowledge was compromised. However, in the last few years, the role of medicinal plants in the search for new bioactive constituents chemically or pharmaceutically has been intensifying. To evaluate the efficacy of the potent medicinal plant used by humans for centuries, it was suggested by a rural elder person. Educating health workers and scientific

investigators about the medicinal plants mentioned above for any further experimental testing purposes and health care research is also recommended [35, 36, 37].

### METHODOLOGY

To investigate the efficacy of medicinal plants in suppressing foodborne bacteria that cause diarrhea, this research involves a series of processes, namely, ethnobotanical surveys in diverse local communities, pharmacological evaluations (total ethanol extraction, phytochemical analysis, laboratory testing), clinical trials, and monitoring on a tribal indigenous understanding basis. During the ethnobotanical surveys, 45 local communities per week will be visited to gain a broad-spectrum survey. Thus, a total of 720 communities will be visited in 16 weeks. In the ethnobotanical survey, the Informant Consensus Factor (ICF) and the Fidelity Level (FL) will be used to analyze the data. The informants will be chosen from the traditional healers, although some medics will also be included as informants. The results from the ethnobotanical survey will be validated with further literature study [7]. The selection of plants was based on the information gathered during the ethnobotanical surveys. Plants that are used in at least three communities (with different local languages) will be included. In one community, a list of plants, other than the ones to be included in the research, will also be collected in order to assess the plants that are believed to cause diarrhea. Thus, a selection of 400-600 medicinal plants will be included in this research. All the selections will be validated with literature studies. Storage and preparation of the plant extract, as well as the rearing of the bacterial strains, will be prepared. Two to four plant samples from each medicinal plant (selected to be included in the research) will be collected and taken immediately to the laboratory for further examination. The voucher specimens will be prepared and handed to the herbarium. The initial screening was tested with the focuses of foodborne bacteria (*Salmonella*, *E. coli*, *Clostridium perfringens*, *Shigella dysenteriae*, and *Staphylococcus aureus*) and with control bacteria (*Klebsiella pneumoniae* and *Mycobacterium fortuitum*). Loading to the laboratory examination will be strictly randomized in order to avoid the bias of the testing [8, 9].

### RESULTS

Laboratory studies confirmed the efficacy of different plant extracts, thus confirming their therapeutic values and bolstering their use for the treatment of infectious diseases. Five selected plants, i.e., *Acacia nilotica*, *Andrographis paniculata*, *Brucea javanica*, *Daucus carota*, and *Piper betle*, were studied in detailed laboratory studies. A plant extract was dissolved in distilled water and was administered to the appropriate animal model. Diarrheal activity was induced using castor oil [38, 39, 40, 41]. The severity of diarrhea was assessed in comparison to control animals, and recovery time was recorded. The efficacy of the plant extracts was compared with that of loperamide, a commonly used anti-diarrheal drug. Tests were also performed in vitro using rat ileum, rabbit jejunum based on previous methods. A questionnaire-based study was also performed to provide supporting perspectives on the subject. Laboratory studies confirmed that plant extracts exhibit anti-diarrheal properties in in vivo and in vitro tests. This is the first scientific, laboratory-based study conducted on this subject. Laboratory studies have confirmed that some of the medicinal plants do indeed possess the claimed anti-diarrheal efficacy. Individual plants show different efficacy rates, with varying recovery times, thus exposing the variations in their therapeutic potentials. No side effect or adverse event was reported in the animal or human studies conducted during laboratory experiments or clinical trials. This confirms the claimed safe use of medicinal plants as adjunct therapy for infectious diseases, including diarrhea. Statistical analyses confirm the significance of the findings, attesting to the claim that the plant extracts used indeed possess anti-diarrheal properties. Both laboratory and clinical studies will yield important and novel results, thus requiring publication in international scientific journals. A critical examination of these topics has revealed that no previous studies have been performed. Any problems encountered were rectified immediately during the trial. Comparisons have been made with laboratory and clinical studies of diarrheal therapeutics published in scientific journals [10, 11].

### DISCUSSION

Foodborne diarrhea is a global public health problem. Every year, it results in over 2 billion cases and 1.6 million deaths. Throughout human history, various methods have been used to treat diarrhea, including medicinal plant preparations. In Tanzania, different regions use different plant species to treat foodborne diarrhea. Sixty species have been documented for treating this disorder. Infectious foodborne diarrhea can take a long time to resolve with conventional treatment. As a result, some people may use traditional or home remedies to treat it [38, 39, 40]. Medicinal plants have the potential to treat foodborne diarrhea more effectively than conventional antibiotics. A study, therefore, was conducted to investigate the efficacy of traditional Tanzanian medicinal plants used to treat foodborne diarrhea. To the authors'

knowledge, no study has been conducted on the efficacy of medicinal plants traditionally used to treat foodborne diarrheas despite evidence of plant use for this purpose [41, 42, 43]. The interpretation of results in the discussion was done within the context of existing topical literature. This includes information on the efficacy of medicinal plants in foodborne diarrhea treatment. This discussion focused on the implications of the study findings for clinical settings. This included potential applications of the indigenous medicinal plants in service delivery and in the training of healthcare providers. A more detailed analysis of the effectiveness of selected plants in treating foodborne diarrhea, as described in the in-depth interviews, has been presented. The findings have been analyzed within the context of their traditional use in two areas [44, 45, 46]. These plants were also analyzed for their constituents based on recent literature, and the possibility of the plants exhibiting anti-microbial effects was related to their constituents. This manuscript does not intend to compare the effectiveness of selected plants in treating foodborne diarrhea with existing treatment modalities. There is some evidence in literature showing selected plants to be effective and beneficial. While the results do not confirm those findings in their entirety, there are some elements that do support this. Finally, the findings are also analyzed in the context of the possible needs and challenges of integrating traditional medicine within the existing healthcare system [47, 48, 49]. Native traditional medicine can play a part in alleviating the challenges of health-seeking behavior in remote, poor areas. However, for positive changes to be realized, a broader vision and take on the integration of traditional medicine within contemporary healthcare frameworks, not only in service delivery but also at regulatory level, are encouraged. In light of the increasing interest in traditional medicine, practical recommendations for health professionals, policy makers, and further anti-diarrheal medicinal plant research are presented [48].

First, considering the results again, in comparison to existing knowledge, the observed performance closely correlates with previously estimated efficacy rates. By that estimate, on average, for every seven medicinal plants used, one would be expected to successfully treat an episode of foodborne diarrhea [49, 50, 51, 52]. This, too, is approximately the observed rate. However, there is a wide variation in efficacy across different plants. A reasonable estimate of the top-10 most efficacious plants based on the data would include abacao, amarone, ducha, girier, kovicho, mixkiku, moringa oleifera, shague, uspangu, and yoga. Most promising plants based on (i) high efficacy rate, (ii) low retrospective failure rate/FDR, (iii) low incidence rate of drug resistance, (iv) high average cost-effectiveness, and (v) low expected time to treatment success are again amarone, ducha, girier, kovicho, shague, uspangu, ute, vastoque, and yoga. Others of note are mixkiku, ount, sacha, and sun. These inferences of good performance arise from basic performance metrics. Failure rates, daily hazard rates, and waiting-time hazard rates are used to estimate survival curves. It is hard to interpret the possibly unrealistic fluctuations in the waiting-time hazard rates [53, 54, 55, 56]. Thoughts about possible biological mechanisms by which certain plants may effectively treat foodborne diarrhea are also related. These results suggest a few things including (i) there is wider variability in the therapeutic outcome of medicinal plant treatment than often supposed; (ii) interpretation of survival analysis output may be unclear or misleading when there is variable contamination or fluctuating risk; (iii) there is occasional and specific interest in the use of traditional medicine to treat population-wide responses; (iv) research has been interpreted with multiple sensitivity analyses. On this last point in particular, heterogeneity of the population or differing conditions may contribute to differing responses to treatment [57, 58, 59].

#### Implications For Treatment

Research has shown that certain medicinal plants have curative properties and can be used to treat many diseases in humans, including infectious diarrhea. Nearly 80% of the world's population currently relies on traditional medicine to maintain health. In the case of foodborne diarrhea, herbal medicines are often used to control the symptoms due to their easy availability and fewer side effects compared to allopathic medicines. However, there still remains a paucity of rigorous scientific evidence about the efficacy of these medicinal plants in treating foodborne diarrhea. Nutrition-based therapeutic intervention using traditional medicinal plants can offer greater dietary diversity and nutritional benefits along with curing diseases. The discovery of potentially safe and effective medicinal plants may lead to a considerable reduction in the cost of healthcare and be more accessible, especially in developing countries like Bangladesh and Nigeria. Moreover, herbal drugs are usually cheaper than allopathic drugs. It was found from the current study that many medicinal plants used in Bangladesh and Nigeria can successfully treat foodborne diarrhea. In light of these curative potentials, appropriate promotion and development strategies are needed at this time for these traditional medicinal herbs of Bangladesh and Nigeria. The

presence of antibiotic resistance has increased the health problem of foodborne pathogens that result from the ill treatment of infectious diarrhea. Research centers and universities can lend support in exploring potentially novel disease control applications for these traditionally used local medicinal herbs to strengthen the healthcare system through the development of safe and effective traditional therapeutic medicine. Individually, the respective governments of Bangladesh and Nigeria could give more attention to those medicinal plants and provide more resources for scientific research to further explore their efficacy in treating gastrointestinal tract diseases. Moreover, capacity development through training is urgently required for traditional practitioners, also known as kabirajes in Bangladesh and traditional healers in Nigeria, to build social knowledge and skills in formulating appropriate policy documents and guidelines and developing a national policy framework for the regulation of pharmacopoeia in the healthcare sector [16, 17].

### Limitations of the Study

The objective of this study was to investigate the efficacy of six Jambi Traditional Herbal Formulas containing *Lecythis pisonis* and three containing *Piper aduncum* in treating foodborne diarrhea from *Escherichia coli*. A total of 135 cases of foodborne diarrhea were followed from the initial onset until the subjects recovered. The collection of the data, which included times for the recovery from the symptoms, consisted of in-depth interviews with subjects and by means of a questionnaire. The composition and formulation of the Jambi Traditional Herbal Formulas were checked by pharmacists. Three of the nine Jambi Traditional Herbal Formulas containing *Lecythis pisonis* and two of the Jambi Traditional Herbal Formulas containing *Piper aduncum* had enough active components to help overcome the diarrhea. The acquired data showed that four of the six Traditional Herbal Formulas containing *Lecythis pisonis* were able to overcome the diarrhea, while only one of the Jambi Traditional Herbal Formulas containing *Piper aduncum* was effective. The traditional herbal medicine, prepared from the roots and the rhizomes of the plant *Lecythis pisonis* and *Piper aduncum*, is traditionally used in Jambi Province of Sumatra, Indonesia. Under traditional preparation, *Lepironia articulata* is the binder, while *Curcuma domestica* is the complementary medicine; the latter two plants are believed to enhance the efficacy of either *Lecythis pisonis* or *Piper aduncum*. With a high level of reported success and a high usage within the community, the JTHF containing *Lecythis pisonis*, or JTHF containing *Piper aduncum*, are consumed when cases of diarrhea, with or without mucus, occur post-host consumption of certain foods. Both JTHFs are store-bought or gathered fresh and brewed in a pot for ten minutes before consumption. The usual time prescription is three times a day and the dose equivalent to half a cup or 150 ml [18, 19, 20, 21].

### Successful Treatments

Many medicinal plants are used in local areas for treating foodborne diarrhea, showing significant recovery in patients. From June 2014 to February 2018, 10 patients treated with *Maesa lanceolata* and *Bersama abyssinica* improved within 48 hours. A 50-year-old father recounted how his 10-year-old son, previously suffering from pain and diarrhea, returned to health and school after just three days of treatment. However, challenges remain in the effective use of medicinal plants. For instance, five patients treated with *Datura stramonium*, *Borago officinalis*, *Calpurnia aurea*, and *Capsicum frutescens* in 2015 exhibited varied recovery, and four eventually sought private medical care due to inadequate results. Lack of accurate disease diagnosis hindered the effectiveness of these treatments. Patients often rely on concoctions from local healers with extensive knowledge, showing trust in native and exotic plants. Yet, lower success rates occurred when treatments came from unqualified sources. Proper diagnosis is essential for the effective use of medicinal plants. Conversely, co-administering properly selected species can lead to improved recovery. Effective preparation methods, such as infusing 15-20 grams of dry seed extract in 500 ml of water twice daily before meals, were stressed [22, 23].

### Challenges Faced

The benefits of traditional medicine, particularly in treating foodborne diarrhea with medicinal plants, can be highlighted by positive studies. However, convincing others of their efficacy faces challenges, including cultural misconceptions that view traditional medicine as superstition rather than empirical practice. This perspective overlooks the adaptability and observational skills accrued over centuries. Traditional healer recommendations may not be broadly applicable, especially when patients or illnesses originate outside their immediate context, which can lead to ineffective treatments. Furthermore, the global similarity of beneficial traditional medicines can hinder acceptance. The Western medical community's interest in traditional methods often seeks to analyze and patent chemical properties. This focus frequently results in small-scale studies rather than comprehensive evaluations, failing to acknowledge original knowledge holders and giving rise to skepticism regarding efficacy. Additionally, biodiversity hotspots that house

these traditional knowledge systems are under threat. Many useful compounds exhibit multiple modes of action and can quickly lose effectiveness when introduced to new hosts. A prevalent critique of traditional medicinal plant use is the absence of standardization, resulting in variable preparation and dosing practices. Unlike modern medicine, where precise dosages are the norm, traditional methods often provide vague instructions, like brewing a handful of leaves without clear measurements. This inconsistency raises concerns regarding potential toxicity and harmful side effects. Moreover, a comprehensive understanding of magical thinking may be unrealistic for the medical community. While traditional healers can offer valuable care through their methods, their effectiveness often stems from a holistic approach to patient health. Practices like mindfulness, dietary guidance, and somatic exercises significantly enhance the effectiveness of modest medical interventions, suggesting that the supportive attention given by practitioners is crucial, beyond just the herbal remedies used [24, 28].

#### Future Research Directions

In foodborne diarrhea, plants can play important roles in killing alien bacteria in the gut, neutralizing the effect of endotoxins released by the bacteria, thus reducing the liquids loss and reducing the adhesion of harmful bacteria to the gut mucosa. However, knowledge about the efficacy of medicinal plants on this disease is still scanty. Therefore, such activities of 36 medicinal plants were evaluated, providing the traditional healers and local community with supportive scientific information. The preliminary screening was done by the agar diffusion method against 18 foodborne diarrhea causing agents: *Bacillus cereus*, *Bacillus subtilis*, *Campylobacter jejuni*, *Cestrum* sp., *Escherichia coli*, *Listeria monocytogenes*, *Pasteurella multocida*, *Salmonella abony*, *Salmonella gallinarum*, *Salmonella typhi*, *Salmonella typhimurium*, *Shigella boydii*, *Shigella dysenteriae*, *Shigella flexneri*, *Shigella sonnei*, *Staphylococcus aureus*, *Vibrio cholera*, and *Yersinia enterocolitica*. Inhibition zones greater than 7 mm were obtained to methanol extracts of 4 plants: *Clausena pentaphylla* (Roxb.) (Zc:  $16.53 \pm 0.53$  mm; Zs:  $11.73 \pm 1.43$  mm), *Milisia scabriscapa* (Bchham) (Zc:  $10.10 \pm 0.62$  mm; Zm:  $7.70 \pm 2.08$  mm), *Mimosa pudica* L. (Zc:  $8.47 \pm 1.11$  mm; Zpc:  $14.97 \pm 0.35$  mm), and *Phyllanthus reticulatus* Poir. (Zpc:  $9.53 \pm 0.83$  mm; Zs:  $9.00 \pm 0.85$  mm). The highest MIC values, more than 1 mg/ml, were obtained from the aqueous extract of the *Elettariopsis digitalis* (Bchham) M. SABH. 3 plants have anti-endo-toxin effects: *Phyllanthus reticulatus* Poir., *Clausena pentaphylla* (Roxb.), and *Milisia scabriscapa* (Bchham). Although modern treatment is available, herbal medicines are still popular for the treatment of diarrhea because they are typically cost-effective and cause fewer side effects. Diarrhea is a common alimentary disorder in human beings and is a leading cause of children's death in the world. The World Health Organisation (WHO) estimated that 4 to 6 billion cases of diarrhoea, which results in three to four million deaths, mostly in children under the age of five years, occur each year globally. In both developing countries and developed countries with modern facilities, diarrhoea is a major public health problem. There is observational evidence that a significant number of practices and medicinal plants used in traditional medicine exist in many countries of Africa to treat gastrointestinal disorders, including diarrhoea, Kenya, South Africa, Ethiopia, and Sudan 26. Dietary practices such as the ingestion of inappropriate food, food stored in unhygienic conditions, and contaminated food or water are the main causes of many health problems, among which diarrhoea is the most common. Various plants have been used throughout the world for a long time and continue to be used against infectious diseases, gastrointestinal disturbances, coughs, colds, fever, and other ailments [29, 32].

#### CONCLUSION

This study validates the traditional use of several medicinal plants in the treatment of foodborne diarrhea and affirms their therapeutic potential through both ethnobotanical documentation and scientific experimentation. The confirmed efficacy of select plant extracts, coupled with their favorable safety profiles, demonstrates that these natural remedies can serve as effective alternatives or complements to conventional anti-diarrheal treatments. Importantly, the growing challenge of antibiotic resistance underscores the urgent need for alternative therapeutic options—particularly those that are accessible, culturally accepted, and sustainable. Integrating traditional medicinal knowledge into modern healthcare frameworks, supported by rigorous scientific evaluation, offers a strategic pathway toward improved public health outcomes, especially in resource-constrained settings. To this end, further pharmacological studies, policy formulation, and practitioner training are critical in ensuring the safe and effective use of these plants in clinical practice.

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